PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 14 September 2000 (14.09.00)	
International application No. PCT/DK00/00003	**Applicant's or agent's file reference** OT 9
International filing date (day/month/year) 04 January 2000 (04.01.00)	**Priority date** (day/month/year) 05 January 1999 (05.01.99)
Applicant HANSEN, Kim, Vejlby	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

07 August 2000 (07.08.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Charlotte ENGER
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 28 September 2000 (28.09.00)	
International application No. PCT/DK00/00003	**Applicant's or agent's file reference** OT 9
International filing date (day/month/year) 04 January 2000 (04.01.00)	**Priority date** (day/month/year) 05 January 1999 (05.01.99)
Applicant HANSEN, Kim, Vejlby	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

03 August 2000 (03.08.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Manu Berrod
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

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INTERNATIONAL SEARCH REPORT

Int. Application No
PCT/DK 00/00003

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04R25/00 G10L21/02 H04R3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G10L H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 98 25214 A (ZIEHE ANDREAS ;GMD FORSCHUNGSZENTRUM INFORMAT (DE); MUELLER KLAUS) 11 June 1998 (1998-06-11) page 2, line 4 -page 10, line 15 page 29, line 6 - line 10	1 10
Y A	US 5 524 056 A (KILLION MEAD ET AL) 4 June 1996 (1996-06-04) column 3, line 37 - line 49; figures column 8, line 16 -column 9, line 30	10 1-3,6-9, 11
X	DE 195 31 388 C (EHLERS FRANK ;SCHUSTER HEINZ GEORG PROF DR (DE)) 25 July 1996 (1996-07-25) page 8, line 5 - line 11	1,5

-/—

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 2000	07/06/2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Authorized officer Gastaldi, G

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 208 786 A (FEDER MEIR ET AL) 4 May 1993 (1993-05-04) column 1, line 60 -column 3, line 51; figures	1,5
A	EP 0 565 479 A (UNIV RAMOT) 13 October 1993 (1993-10-13) page 4, line 58 -page 5, line 51	1,5
A	TANIGUCHI T ET AL: "Blind signal separation for recognizing overlapped speech" J. ACOUST. SOC. JPN. (E) (JAPAN), JOURNAL OF THE ACOUSTICAL SOCIETY OF JAPAN (E), NOV. 1998, ACOUST. SOC. JAPAN, JAPAN, vol. 19, no. 6, pages 385-390, XP002108812 ISSN: 0388-2861 abstract	1,5
A	US 5 706 402 A (BELL ANTHONY J) 6 January 1998 (1998-01-06) cited in the application column 1, line 15 -column 8, line 39	1,5

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int Application No
PCT/DK 00/00003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9825214 A	11-06-1998	DE 19652336 A	04-06-1998
		EP 0943130 A	22-09-1999
US 5524056 A	04-06-1996	EP 0664071 A	26-07-1995
		WO 9424834 A	27-10-1994
DE 19531388 C	25-07-1996	NONE	
US 5208786 A	04-05-1993	IL 102738 A	04-08-1996
		WO 9305503 A	18-03-1993
EP 0565479 A	13-10-1993	IL 101556 A	04-08-1996
		JP 6021838 A	28-01-1994
		US 5539832 A	23-07-1996
US 5706402 A	06-01-1998	AU 4596596 A	19-06-1996
		WO 9617309 A	06-06-1996

CLAIMS

1. A method for reduction of noise in an audio signal containing noise and a target signal, the method comprising:
providing at least two input signals, each having different contents of the target signal and the noise, hereby providing different input signals;
processing the input signals by means of an independent component analysis based on the differences of the content of the at least two input signals, hereby determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements;
outputting a part of the audio signal.

2. A method according to claim 1, wherein the at least two input signals are picked up at least at two mutually distanced locations;

3. A method according to claim 1 or 2, wherein two or more output signals are produced and where a possibility exists for switching between the two or more output signals or combinations of these.

4. A method according to any of the claims 1-3, wherein two or more output signals are produced and where an automatic switching between the two or more output signals according to a predetermined scheme is provided.

5. A device for use in reducing noise in an audio signal containing noise and a target signal, the device comprising:
at least two input channels;
signal processing means in connection with the input channels, which provides input signals to the signal processing means;
a receiver in connection with the signal processing means;

the signal processing means being adapted to process the signals by means of an independent component analysis method based on differences of signal-to-noise ratios of the inputs signals in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

6. A device according to claim5, wherein the device comprises at least two microphones having a mutually different signal-to-noise ratio in relation to a desired target signal, hereby being able to provide different input signals for the respective input channels.

7. A device according to claim 5 or 6, wherein the device comprises at least a directional microphone and an omni-directional microphone.

8. A device according to claim 5, 6 or 7, wherein two or more output signals are produced and where means are provided for switching between the two or more output signals or combinations of these.

9. A method according to claim 5, 6 or 7, wherein two or more output signals are produced and where automatic switching means are provided for switching between the two or more output signals according to a predetermined scheme.

10. A hearing aid comprising at least two microphones each having a different signal-to-noise ratio in relation to a desired target signal; signal processing means in connection with the at least two microphones; an amplifier in connection with the signal processing means; a receiver in connection with the amplifier for outputting a signal from the amplifier; the signal processing means being adapted to process the signals by means of an independent component analysis method based on the

input from the two microphones having a mutually different signal-to-noise ratio in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

11. A hearing aid according to claim 12, wherein the hearing aid comprises a directional microphone and an omni-directional microphone.

PATENT COOPERATION TREATY

CONFIRMATION OF FAX

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

CHRISTENSEN,Mikael T.
OTICON A/S
Strandvejen 58
DK-2900 Hellerup
DANEMARK

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	18.05.2001
Applicant's or agent's file reference: OT 9	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/DK00/00003	04/01/2000	05/01/1999

Applicant
OTICON A/S et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Smits, A Tel.+31 70 340-3596

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREA

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
OT 9		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/DK00/00003	04/01/2000	05/01/1999
International Patent Classification (IPC) or national classification and IPC		
H04R25/00		
Applicant		
OTICON A/S et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
03/08/2000	18.05.2001
Name and mailing address of the international preliminary examining authority:	Authorized officer
European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx 31 651 epo nl Fax: +31 70 340 - 3016	Gastaldi, G Telephone No. +31 70 340 2968

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/DK00/00003

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, pages:

1-13 as originally filed

Claims, No.:

1-6 as received on 29/03/2001 with letter of 26/03/2001

Drawings, sheets:

1/4-4/4 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-6
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-6
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-6
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

2.0). Reference is made to the following document:

D1: US 5 208 786 A.

2.1). The present application satisfies the criterion set forth in Article 33 (2)(3) PCT in conjunction with Rules 64 and 65 PCT because the subject-matter of claims 1-6 is novel and involves an inventive step.

Claim 1

2.2). Prior art document D1 describes a signal processing system including a plurality of detectors for receiving plural observed signals, which results from plural sources signals subjected to an unknown transfer function. A processor receives the observed signals and estimates the components of the transfer function which are used to produce a filter for reconstructing the input source signals. The processing of the observed signals is based on the independent component analysis (ICA) in order to remove unwanted signal elements.

In connection with independent component analysis (ICA) of sound signals it is known to arrange at least one of the detectors close to the target sound source I order to achieve enhanced signal to noise ratio from this detector, see D1, figure 7. In many devices such as hearing aids this is not a option, which limits there benefits of using in connection with these devices. The invention seeks a solution to this problem and by the feature of the independent claims

According to claim 1 this is done by using microphones with mutually different directionality whereby it is ensured that one of the input signals has a better signal to noise ratio with respect to the target signal than the other input signals. By doing this, the independent component analysis (ICA) can use input signals as the target signals and thereby the performance of the ICA may be enhanced.

D1 does not mention the use of microphones with different directionality in connection with the ICA method. It neither suggests it in an obvious manner.

Therefore the combination of features according to the present claim 1 is neither disclosed nor rendered obvious by the disclosure of document D1.

Moreover there is no indication in the remaining available prior art which suggests the combination as in present claim 1.

Therefore the subject-matter of the independent claim 1 currently on file is novel and involves an inventive step according to the criterion set forth in Article 33(2) and 33(3) PCT in conjunction with Rules 64(1)-(3) and 65(1)(2) PCT.

Claims 2-4

2.3). The dependent claims 2-4 define particular embodiments of claim 1 which are not considered obvious in view of the available prior art.

Claim 5

2.4). Independent claim 5 defines another way of solving the problem. It consists in making use of a beamforming. At least two microphones are used and the beamforming will add directivity to a signal which is fed to an input channel of the signal processing means together with a microphone signal without beamforming. In this way directionality and thus improved signal to noise ratio is ensured for one of the signal processing means and thereby enhanced ICA performance is ensured.

D1 does not mention the use of beamforming in connection with the ICA method. It neither suggests it in an obvious manner.

Therefore the combination of features according to the present claim 5 is neither disclosed nor rendered obvious by the disclosure of document D1.

Moreover there is no indication in the remaining available prior art which suggests the combination as in present claim 5.

Therefore the subject-matter of the independent claim 5 currently on file is novel and involves an inventive step according to the criterion set forth in Article 33(2) and 33(3) PCT in conjunction with Rules 64(1)-(3) and 65(1)(2) PCT.

Claim 6

2.5). Claim 6 defines a hearing aid having substantially the same features as the device claimed in the present claim 1.
Therefore the subject-matter of the independent claim 6 currently on file is novel and involves an inventive step according to the criterion set forth in Article 33(2) and 33(3) PCT in conjunction with Rules 64(1)-(3) and 65(1)(2) PCT.

Re Item VII

Certain defects in the international application

1). The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

2). The document D1 has not been identified in the description nor has the relevant background art disclosed therein been discussed. The requirements of Rule 5.1(a)(ii) PCT are, thus, not fulfilled.

3). The description is not in conformity with the claims as required by Rule 5.1(a)(iii) PCT, see also PCT/GL/IPE III-4.3.

CLAIMS

1. A device for use in reducing noise in an audio signal containing noise and a target signal, the device comprising:
at least two input channels each receiving a signal from a respective microphone, at least two of the microphones having mutually different directionality;
signal processing means in connection with the input channels, which provides input signals to the signal processing means;
a receiver in connection with the signal processing means;
the signal processing means being adapted to process the signals by means of an independent component analysis method based on differences of signal-to-noise ratios of the inputs signals in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

2. A device according to claim 1, wherein the device comprises at least a directional microphone and an omni-directional microphone.

3. A device according to claim 1, wherein two or more output signals are produced and where means are provided for switching between the two or more output signals or combinations of these.

4. A device according to claim 1 or 2, wherein two or more output signals are produced and where automatic switching means are provided for switching between the two or more output signals according to a predetermined scheme.

5. A device for use in reducing noise in an audio signal containing noise and a target signal, the device comprising:
at least two microphones and beamforming means to make a beamforming of the input signals from the microphones and hereby adding directionality to the signal of at least one of at least two input channels;

signal processing means in connection with the input channels, which provides input signals to the signal processing means;

a receiver in connection with the signal processing means;

the signal processing means being adapted to process the signals by means of an independent component analysis method based on differences of signal-to-noise ratios of the inputs signals in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

6. A hearing aid comprising at least two microphones each having a different signal-to-noise ratio in relation to a desired target signal; signal processing means in connection with the at least two microphones; an amplifier in connection with the signal processing means; a receiver in connection with the amplifier for outputting a signal from the amplifier; the signal processing means being adapted to process the signals by means of an independent component analysis method based on the input from the two microphones having a mutually different signal-to-noise ratio in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal, wherein the hearing aid comprises a directional microphone and an omni-directional microphone.

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :
H04R 25/00, G10L 21/02, H04R 3/00

A1

(11) International Publication Number: WO 00/41441

(43) International Publication Date: 13 July 2000 (13.07.00)

(21) International Application Number: PCT/DK00/00003

(22) International Filing Date: 4 January 2000 (04.01.00)

(30) Priority Data:
99610002.0 5 January 1999 (05.01.99) EP

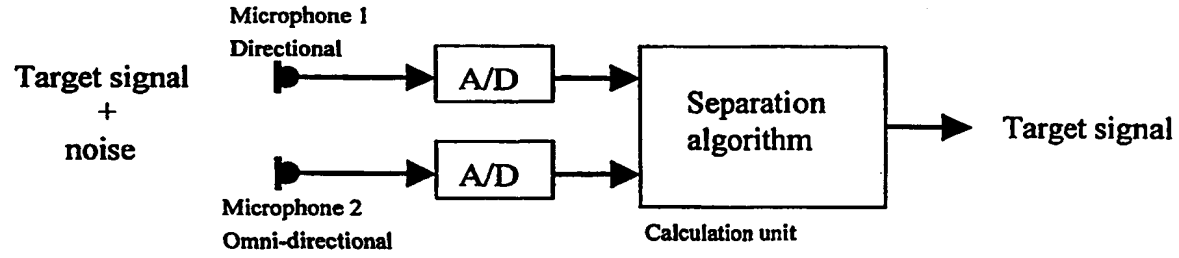
(71) Applicant *(for all designated States except US)*: OTICON A/S [DK/DK]; Strandvejen 58, DK–2900 Hellerup (DK).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: HANSEN, Kim, Vejlby [DK/DK]; Skovbakken 56, DK–3520 Farum (DK).

(81) Designated States: AU, CA, JP, US.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A METHOD AND A DEVICE FOR PROVIDING IMPROVED SPEECH INTELLIGIBILITY



(57) Abstract

The invention relates to a method for reduction of noise in an audio signal containing noise and a target signal, the method comprising, providing at least two input signals; processing the input signals by means of an independent component analysis; hereby determining statistical dependencies of signal elements of the two input signals and determining whether statistical dependent signal elements form part of the target signal; outputting a part of the audio signal. The invention further relates to a device for use in reducing noise in an audio signal containing noise and a target signal.

TITLE

A method and a device for providing improved speech intelligibility.

BACKGROUND OF THE INVENTION

The invention relates to a method for the reduction or elimination of an eventual noise contribution to an audio signal, which is picked up by sensor means. The invention further relates to a device for reduction or elimination of an eventual noise contribution to an audio signal, which is picked up by sensor means.

The invention will for practical reasons be explained in connection with a hearing aid. The invention is however not limited to this field as it may be implemented in other technical fields where an audio signal is picked up by sensor means.

Although modern hearing aids have come a long way in providing amplification well suited to the hearing impaired user, many hearing impaired people still have problems understanding speech in noise. The issue of improving the speech intelligibility by improving the ratio between the desired speech signal and the noise has already been addressed in many ways, mostly based on directionality.

As of the present day the commercially available directional devices are either an acoustical two-port design as disclosed in US patent no. 5524056, an electrical combination of the outputs of two omni-directional microphones as disclosed in J. Malsano & W. Hottinger, "A method for electronically beam forming acoustical signals and acoustical sensorapparatus", European Patent EP 0 820 210 A2, or an electrical combination of several microphones into a single highly directional device to be used physically externally to the hearing aid as disclosed in W. Soede, A.J. Berkhout & F.A. Bilsen, 1993, "Development

of a directional hearing instrument based on array technology", J. Acoust. Soc. Am. 94(2), p. 785-798.

These previously known devices are thus characterised by a certain amount of directionality pointing in the forward direction with respect to the user, and characterised by a time-invariant processing of the individual ingoing sensor signals. Although the use of directionality to some extent gives improved speech intelligibility, the directionality is in many situations non-satisfactory and there is a requirement of further improving speech inteligibility.

Directionality is also used in a different group of proposed devices, which make use of adaptive noise cancelling principles as disclosed in B. Widrow, J. Glover, J. McCool, J. Kaunitz, C. Williams, R. Hern, J. Zeidler, E. Dong & R. Goodlin, 1975, "Adaptive noise cancelling: Principles and applications", IEEE Proceedings 63, p. 1692-1716. Thus, a number of microphones, which may be mounted either in hearing aids at each ear of the user, on a headband or in a single hearing aid shell, are combined to form estimates of the interfering noise from which the target signal is removed. A signal containing as much target signal as possible is also formed, and these signals are then used as inputs to an adaptive noise canceller. These devices work on the assumption that the target speech signal impinges from a certain predetermined direction, and are characterised by a directionality and a processing of the individual ingoing sensor signals, which is adaptively varying with time. Further, these devices are characterised by the use of the adaptive noise canceller, as disclosed in P.M. Zurek, J.E. Greenberg & P.M. Peterson, 1990, "Adaptive beamforming for noise reduction". United States Patent 4,956,867; P.V.F. Clough & N.A. Lobo, European Patent 0084892; and J. Vanden Berghe & J. Wouters, 1998, "An adaptive noise canceller for hearing aids using two nearby microphones", J. Acoust. Soc. Am. 103(6), p. 3621-3626.

Although the use of adaptive noise cancelling based on directionality to some extend gives improved speech intelligibility, the directionality is in many

situations non-satisfactory in this respect, as it is the case in connection with the use of directionality alone.

Recently, several researchers have published a new principle, which is called independent component analysis (ICA):

1. J. Herault & C. Jutten, "Space or Time adaptive signal processing by neural network models", Neural Networks for Computing, AIP Conference Proceedings 151, Snowbird, Utah, pp. 207-211, 1986.
2. A.J. Bell, United States Patent 5,706,402.
3. A.J. Bell & T.J. Sejnowski, "An information-maximisation approach to blind separation and blind deconvolution", Technical Report no. INC-9501, February 1995, Institute for Neural Computation, UCSD, San Diego, CA 92093-0523.
4. T.W. Lee, M. Girolami, A.J. Bell & T.J. Sejnowski, "A unifying information-theoretic framework for independent component analysis", Computers & Mathematics with applications, 1998 in press.
5. T.W. Lee, A.J. Bell & R. Orglmeister, "Blind source separation of real world signals", Proceedings ICNN, USA, 1997.
6. T.W. Lee, A.J. Bell & R. H. Lambert, "Blind separation of delayed and convolved sources", Advances in Neural Information Processing Systems 9, 1997 MIT Press, Camvridge MA pp. 758-764.
7. P. Smaragdis, 1997, "Efficient blind separation of convolved sound mixtures", IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk Mountain House, New Paltz, New York.
8. K. Torkkola, "Blind separation of delayed sources based on information maximation", Proceedings of the IEEE international conference on acoustic, speech and signal processing, May 7-10 1996, GA, USA.
9. K. Torkkola, "Blind separation of convolved ources based on information maximization", IEEE workshop on neural network for signal processing, Kyoto, Japan, Sept 4-6, 1996.
10. J.F. Cardoso, "Equivariant adaptive source separation", IEEE Transactions on Signal Processing 44(12), 1996.

11. S. Amari, A. Cichocki, H. H. Yang, "A new learning algorithm for blind signal separation", Advances in neural information Processing systems 8. MIT Press, 1996.

WO 98/25214 discloses a standard ICA method of signal separation where it is assumed that the sources that generate the sensor signals are stationary. The same assumption applies to the sensor positions and the source signal characteristics. In a real world application these assumptions are obviously violated. WO 98/25214 considers how a standard ICA method should be modified to cope with a non-stationary situation. This comprises a scheme for choosing the learning rate of the ICA algorithm according to online measures of the sensor signal characteristics.

US 5,524,056 discloses aspects where the frequency shaping circuit, which ensures that the frequency responses of directional and omni-directional microphones are similar for frontal incidence of sound. The D-Mic thus contains an arrangement of microphones similar to the two-sensor configuration proposed in our patent, but the combination with an ICA algorithm is not mentioned at all.

DE 195 31 388 C1 discloses similarly to WO 98/25214 an extension of a standard ICA algorithm. In this case an eventual non-linear mixing of the ingoing source signals is taken into account. Sensor arrangement and the question of how to make sure that target signal is chosen as the output of the ICA algorithm, are not discussed at all.

US 5,208,786 discloses only second order statistical moments whereas an ICA algorithm considers higher order statistical moments in the signal separation, The disclosed method is also known as decorrelation or Principal Component Analysis (PCA). Again, sensor arrangement and the question of how to make sure that target speech signal is chosen as the output of the algorithm, are not discussed.

EP 0 565 479 A1 discloses a frequency domain realisation of a standard ICA algorithm. The sensor arrangement and the question of how to make sure that target signal is chosen as the output of the ICA algorithm, are not discussed.

US 5,706,402 discloses what has become standard ICA. Thus it outlines the technical background of the present invention. The sensor arrangement and the question of how to make sure that target signal is chosen as the output of the ICA algorithm are not discussed,

Paper XP-002108812 discloses an experimental application of a standard ICA algorithm in a laboratory setting with speech and noise signals in an anechoic stationary environment. The sensor arrangement is two directional microphones placed on top of each other facing in directions 90 degrees apart. No explanation for the particular choice of sensor configuration is given, and the method with which a particular output signal from the ICA signal separation algorithm has been designated as the target speech signal is not discussed at all.

The objective of ICA is to recover the underlying independent source signals given only sensor observations that are linear mixtures of the original source signals. The only assumption of ICA is that the original source signals are statistically independent, otherwise the statistics of the source signals and the mixing of these into the sensor signals may be unknown. In contrast to correlation-based transformations such as Principal Component Analysis (PCA, I.T. Jolliffe, Principal Component Analysis, 1986, Springer Verlag), which decorrelates signals according to 2^{nd}-order statistics, ICA also reduces higher-order statistical dependencies, in terms of maximising joint output entropy, in order to extract statistically independent signal components.

In the linear blind signal separation problem, N signals, $\mathbf{s}(t) = [s_1(t),...,s_N(t)]^T$, are mixed so that an array of N sensors picks up a set of signals $\mathbf{x}(t) = [x_1(t),...,x_N(t)]^T$, each of which has been mixed, delayed and filtered as follows

$$x_i(t) = \sum_{j=1}^{N} \sum_{k=0}^{M-1} a_{ijk} s_j(t - D_{ij} - k)$$

where D_{ij} are entries in a matrix of delays and $\mathbf{a}_{ij}$ are the M- tap filter coefficients between the jth source and the ith sensor. The problem is to invert this scrambling without knowledge of it, thus recovering the original signals $\mathbf{s}(t)$ given only the $\mathbf{x}(t)$ signals. Finding this inverse scrambling is a challenging task since no informations are provided about the mixing nor the signals (hence the term blind separation). The type of architecture chosen for inverting the scrambling is important and can be made in numerous ways. An accurate architecture for inverting a M-tap filter is an infinite impulse response (IIR) filter with M coefficients. However, IIR filters are limited to have poles inside the unit circle, which imply that a stable filter only exists for a minimum phase system. FIR filters may be used to approximate the inverse solution. Thus the inverse scrambling is performed according to

$$u_i(t) = \sum_{j=1}^{N} \sum_{k=0}^{M-1} w_{ijk} x_j(t - d_{ij} - k)$$

which has filters, $\mathbf{w}_{ij}$, and delays d_{ij}, which supposedly reproduce, at the output $\mathbf{u}(t)$, the original uncorrupted source signals, $\mathbf{s}(t)$, apart from a scaling factor for each signal and a permutation of signals.

Several algorithms have been proposed for the blind separation of linear mixtures. Bell and Sejnowski (3) proposed to learn the separating process by minimising the mutual information between components of $\mathbf{y}(t) = g(\mathbf{u}(t))$, where g is a non-linear function approximating the cumulative probability density function of the sources. They showed that for positively kurtotic

signals (like speech) minimising the mutual information between components of $\mathbf{y}(t)$ is equal to maximising the entropy of $\mathbf{y}(t)$, which can be written as $H(\mathbf{y}) = -E[\ln(f_y(\mathbf{y}))]$, where $f_y(\mathbf{y})$ denotes the probability density function of $\mathbf{y}(t)$. Denoting the determinant of the Jacobian of the whole unmixing process by $|J|$, $f_y(\mathbf{y})$ can be written as $f_x(\mathbf{x})/|J|$ (the Jacobian is a matrix with entries of $\partial y_i / \partial x_j$). Maximising the entropy of the output leads to maximising $E[\ln(|J|)]$, which in turn can be developed into a stochastic gradient ascent rule using instances of $\mathbf{x}(t)$ and $\mathbf{y}(t)$, instead of using the expectation. Thus

$$\Delta \mathbf{W} \propto (1 - 2\mathbf{y}(t))\mathbf{x}(t)^T + [\mathbf{W}^T]^{-1}$$

where $g(u) = 1/(1+e^{-u})$ is used to approximate the cdf.

The algorithm can be made more efficient and independent of the conditioning of the mixing process (matrix) by using the so-called natural gradient instead of the absolute gradient, see Amari (11).

One particular proposed application of ICA is within electroencephalographic (EEG) recording of scalp potentials in humans and related brain activity measurements.

The application of the ICA to hearing aids has also been mentioned in H. Sahlin, "Blind signal separation by second order statistics", Ph.D. thesis, Chalmers University of Technology, Technical Report no. 345, Sweden, 1998, but it has so far never been suggested how the implementation of this technique could be realised in connection with audio systems in order to improve speech intelligibility.

Based on this prior art the objective of the present invention is to provide a method and a device for reducing noise in an audio signal comprising both noise and target signal, which method and device has an increased

functionality and reliability compared with the prior art within the audio field of technology.

SUMMARY OF THE INVENTION

This is achieved by means of a method comprising the steps of:
providing at least two input signals, each having different contents of target signal and noise;
processing the two input signals;
the processing comprising use of an independent component analysis or a similar technique based on the differences of the at least two input signals, hereby determining whether statistical dependent signal elements are present and removing at least part of unwanted signal elements;
outputting a part of the audio signal.

The target signal is defined as the signal coming from in front of the device performing the method, whereas other signals are considered as noise signals. In case of no specific well-defined source signal and cases laying outside the assumed set-up, the noise elimination will disappear meaning that the signal processing strategy will pass the input signals unaltered to the outputs.

In a preferred embodiment the method comprises at least two input signals, which are picked up at least at two mutually distanced locations. Hereby one signal contains the target signal with a higher signal-to-noise ratio than the other input signal. In this case the sensor may be identical.

In a further preferred embodiment the method comprises at least two input signals, which are based on differences in the directionality, preferably a directional and an omni-directional sensor. Hereby it becomes possible to determine the origin of the respective signal components based on the differences of the directionality applied when sensing the two input signals.

The different embodiments show that the differences in signal-to-noise ratio is based on the actual situation of use, which means that it is the mutual differences in signal-to-noise ratio in relation to a desired target signal, which is relevant, and not the signal-to-noise ratio of the sensor means itself.

In a further preferred embodiment two or more output signals are produced and where a possibility exists for switching between the two or more output signals or combinations of these. Alternatively an automatic switching between the two or more output signals according to a predetermined scheme is provided. Hereby it becomes possible to make a choice of the actual influence of the separation method on the noise canceling in the actual situation or at least have a change according to the actual choice of the predetermined scheme, which may be adapted for switching at different listening environments.

The objective of the invention is further achieved by means of a device comprising:
at least two input channels;
signal processing means in connection with the input channels, which provides input signals to the signal processing means;
a receiver in connection with the signal processing means;
the signal processing means being adapted to process the signals by means of an independent component analysis method or a similar method based on differences of signal-to-noise ratios of the input signals in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

In a preferred embodiment the device comprises two sensors, preferably microphones, having different signal-to-noise ratio (S/N-ratio). One of the sensors is chosen as the target sensor. Hereby it becomes possible to separate

the respective signal components based on the noise content of the further sensor.

In a preferred embodiment the device comprises a directional microphone and an omni-directional microphone. Hereby the directional microphone will preferably contain the desired output signal based on the position of the user facing the desired audio signal source.

In a preferred embodiment the two microphones are mutually distanced. Hereby it becomes possible to determine the origin of the respective signal components based on a time delay in reception of the two input signals. This makes it possible to make a beamforming of the input signals hereby possibly adding directionality to at least one of the inputs. Other ways of beamforming may be used in this connection.

In a preferred embodiment two or more output signals are produced and means are provided for switching between the two or more output signals or combinations of these. Alternatively means are provided for automatic switching between the two or more output signals according to a predetermined scheme.

Due to the fact that most hearing impaired have a hearing disorder which makes it even more difficult than for normal hearing persons to separate a target signal from the noise, which is often present in a speech situation, the invention is particularly relevant in connection with the technical field of hearing aids.

The invention therefor further relates to a hearing aid comprising: at least two microphones for audio signal input; signal processing means in connection with the microphones; an amplifier in connection with the signal processing means; a receiver in connection with the amplifier for outputting a signal from the amplifier; the signal processing means being adapted to process the signals

by means of an independent component analysis method or a similar method based on the input from the at least two microphones, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

The hearing aid according to the invention may further comprise the features set forth above, either separate or in combination.

Other fields of relevant use of the invention may be telecommunication or audio systems. In such systems the input and output may be connected to antennas or similar transmission and receiving means or may comprise microphones as input means as in the case of a hearing aid. Other elements of such systems may be standard elements, as these are not influenced by the signal processing according to the invention.

The invention will be described more detailed with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing the principles of the invention;

Fig. 2 is a schematic diagram showing the principles of an implemented version of the invention;

Fig. 3 is a schematic diagram showing the principles of an implemented version of the invention;

Fig. 4 is a schematic diagram showing the implemented version of the invention as shown in fig. 2 further implemented in a hearing aid.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The fundamental principle of the invention is schematically shown in fig. 1. The invention is basically a system, e.g. a hearing aid, with two or more sensors and a calculation unit. The calculation unit carries out the separation of the target and noise signals, by using the independence of the mixed signals according to ICA or a similar method comprising the basics of the ICA. The sensors are arranged so that one is positioned to receive sound primarily from a target direction in front, whereas the others have arbitrary characteristics that do not specifically favour the target direction. Hereby, it is possible to use the technique of independent component analysis to separate the desired signal, which impinges from the target direction, from the disturbing noise signals, which impinge from any other directions.

To illustrate the invention, an example is given of a system implementing signal processing as described above. Fig. 2 schematically shows the signal processing system. The system comprises a directional and an omni-directional microphone, and a digital signal processing unit implementing the signal separation algorithm. Using the directional microphone gives the target direction from in front of the user, whereas the omni-directional microphone gives a signal equally representing all signals around the head of the user.

A particularly important property of the independent component analysis is that it separates convolved and delayed source signals, where each independent source signal is defined as a signal which appears in the same way within each mixing process. Another important characteristic about the independent component analysis is that knowledge about the ratio of the source signals within the mixed signals can be used for classifying the separated signals. If for instance one source signal appears with a significantly better signal to noise ratio in one of the sensor signals, this information can be used to ensure that this source signal always will appear in a fixed output. Within the present invention these two characteristics combined with an appropriate placement of at least two sensors are exploited to eliminate signals not coming from in front of the user of the device.

From fig. 3 an embodiment appears, which comprises the features of the embodiment of fig. 2, but where the signal processor produces two output signals. By means of switching means one of the two output signals may be selected for further processing, e.g. amplification, or for output.

From fig. 4 an embodiment appears as a hearing aid according to the invention. The essential components of the hearing aid comprise two microphones, preferably a directional microphone and an omni-directional microphone, and an A/D converter connected to each of the microphones. The A/D converters are connected to a digital signal processor, which is adapted to perform the ICA method on the incoming signals. The signal from the signal processor is then lead to an amplifier and from this through a D/A converter to a receiver for performing the output of the processed signal. The devices of the figs. is in a usual manner powered by means of usual power sources, such as batteries.

CLAIMS

1. A method for reduction of noise in an audio signal containing noise and a target signal, the method comprising:
providing at least two input signals, each having different contents of the target signal and the noise, hereby providing different input signals;
processing the input signals by means of an independent component analysis based on the differences of the content of the at least two input signals, hereby determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements;
outputting a part of the audio signal.

2. A method according to claim 1, wherein the at least two input signals are picked up at least at two mutually distanced locations;

3. A method according to claim 1 or 2, wherein two or more output signals are produced and where a possibility exists for switching between the two or more output signals or combinations of these.

4. A method according to any of the claims 1-3, wherein two or more output signals are produced and where an automatic switching between the two or more output signals according to a predetermined scheme is provided.

5. A device for use in reducing noise in an audio signal containing noise and a target signal, the device comprising:
at least two input channels;
signal processing means in connection with the input channels, which provides input signals to the signal processing means;
a receiver in connection with the signal processing means;

the signal processing means being adapted to process the signals by means of an independent component analysis method based on differences of signal-to-noise ratios of the inputs signals in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

6. A device according to claim5, wherein the device comprises at least two microphones having a mutually different signal-to-noise ratio in relation to a desired target signal, hereby being able to provide different input signals for the respective input channels.

7. A device according to claim 5 or 6, wherein the device comprises at least a directional microphone and an omni-directional microphone.

8. A device according to claim 5, 6 or 7, wherein two or more output signals are produced and where means are provided for switching between the two or more output signals or combinations of these.

9. A method according to claim 5, 6 or 7, wherein two or more output signals are produced and where automatic switching means are provided for switching between the two or more output signals according to a predetermined scheme.

10. A hearing aid comprising at least two microphones each having a different signal-to-noise ratio in relation to a desired target signal; signal processing means in connection with the at least two microphones; an amplifier in connection with the signal processing means; a receiver in connection with the amplifier for outputting a signal from the amplifier; the signal processing means being adapted to process the signals by means of an independent component analysis method based on the

input from the two microphones having a mutually different signal-to-noise ratio in relation to a desired target signal, the processing comprising determining whether statistical dependent signal elements are present and removing at least part of the unwanted signal elements, thereby enhancing other parts of the audio signal.

11. A hearing aid according to claim 12, wherein the hearing aid comprises a directional microphone and an omni-directional microphone.

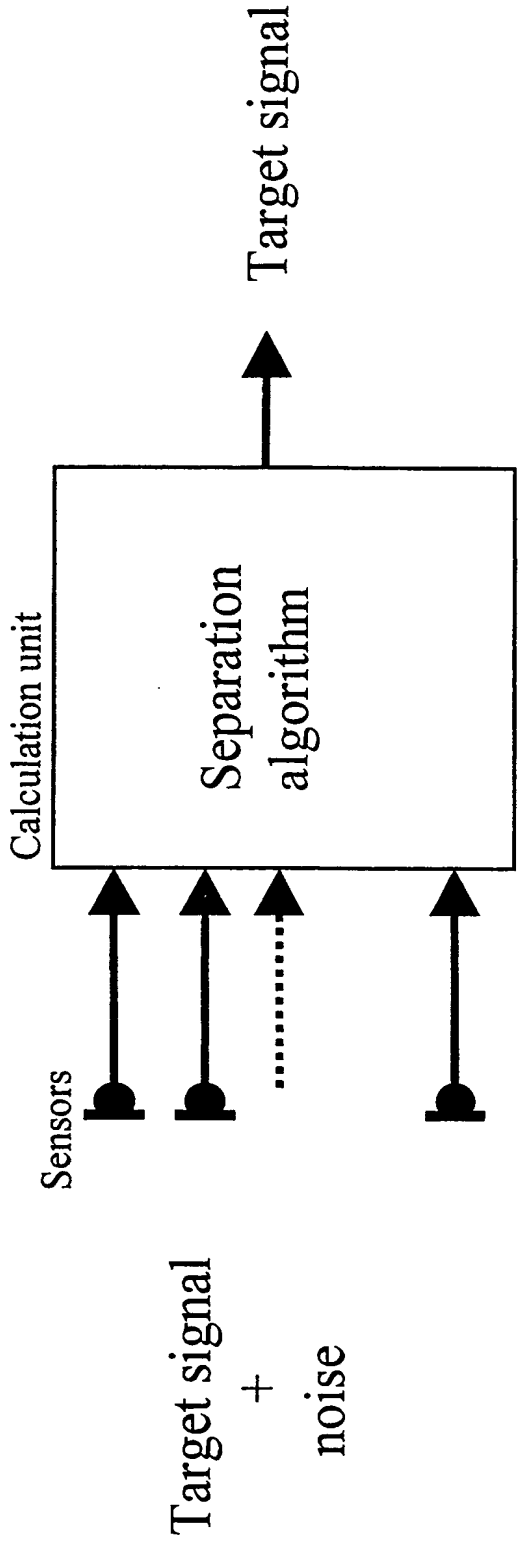

Target signal
Calculation unit
Separation algorithm
Sensors
Target signal + noise

FIG. 1

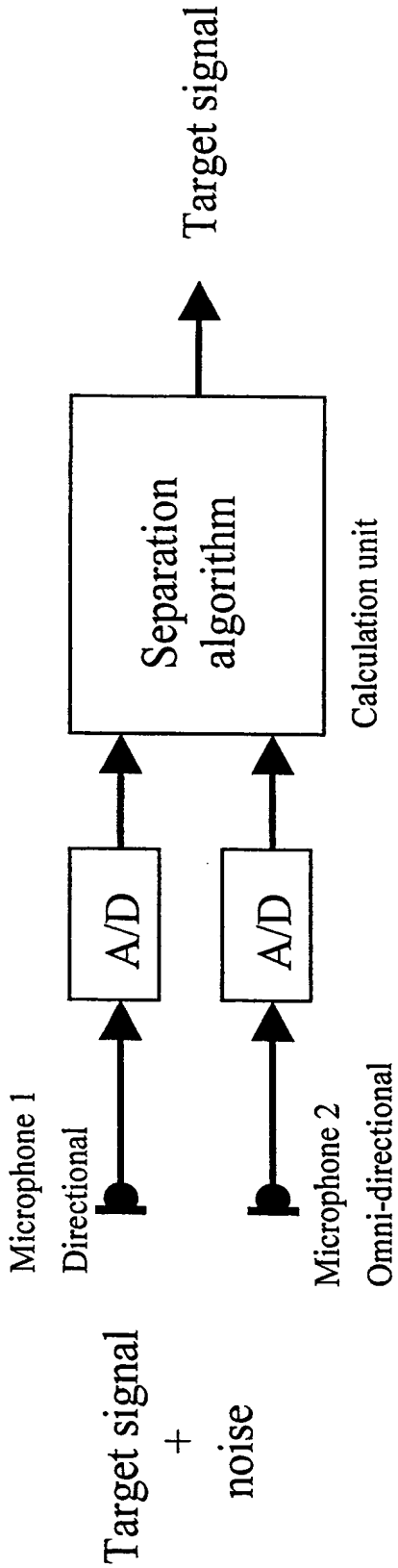

Target signal
Separation algorithm
Calculation unit
A/D
A/D
Microphone 1
Directional
Microphone 2
Omni-directional
Target signal
+
noise

FIG. 2

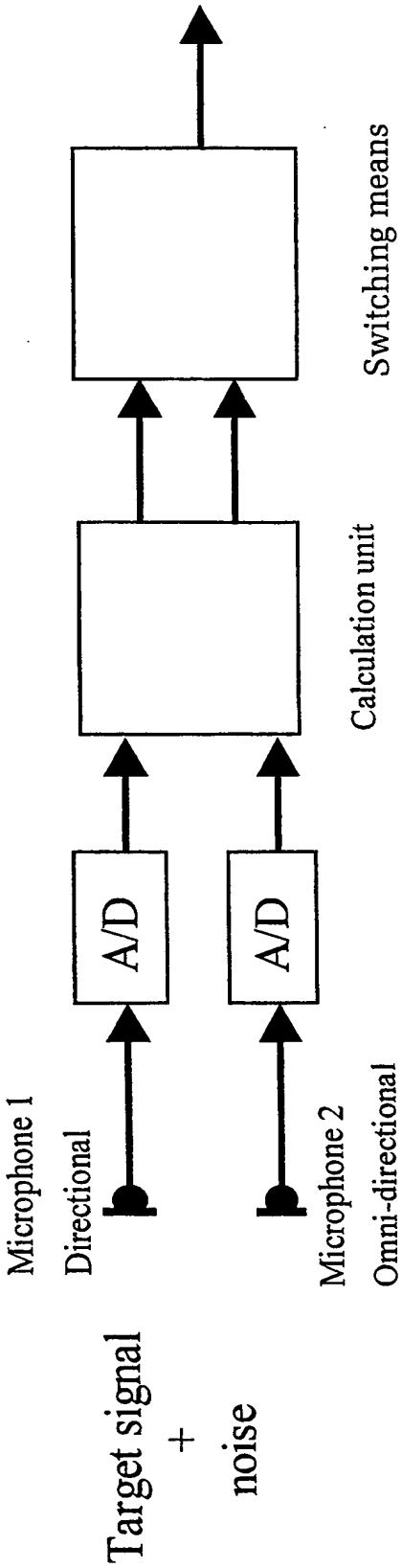

Target signal
+
noise
Microphone 1
Directional
Microphone 2
Omni-directional
A/D
A/D
Calculation unit
Switching means

FIG. 3

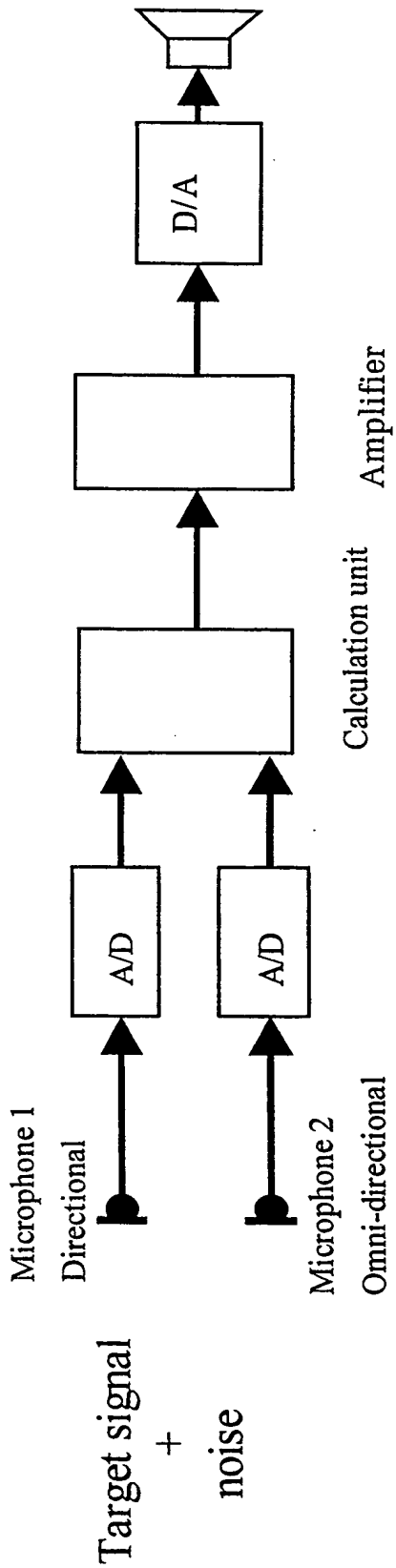

Target signal
+
noise
Microphone 1
Directional
Microphone 2
Omni-directional
A/D
A/D
Calculation unit
Amplifier
D/A

FIG. 4

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
OT 9		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/DK00/00003	04/01/2000	05/01/1999
International Patent Classification (IPC) or national classification and IPC H04R25/00		
Applicant OTICON A/S et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
03/08/2000	18.05.2001
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized officer Gastaldi, G Telephone No. +31 70 340 2968

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/DK00/00003

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-13	as originally filed				

Claims, No.:

1-6	as received on	29/03/2001	with letter of	26/03/2001	

Drawings, sheets:

1/4-4/4	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-6
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-6
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-6
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

2.0). Reference is made to the following document:

D1: US 5 208 786 A.

2.1). The present application satisfies the criterion set forth in Article 33 (2)(3) PCT in conjunction with Rules 64 and 65 PCT because the subject-matter of claims 1-6 is novel and involves an inventive step.

Claim 1

2.2). Prior art document D1 describes a signal processing system including a plurality of detectors for receiving plural observed signals, which results from plural sources signals subjected to an unknown transfer function. A processor receives the observed signals and estimates the components of the transfer function which are used to produce a filter for reconstructing the input source signals. The processing of the observed signals is based on the independent component analysis (ICA) in order to remove unwanted signal elements.

In connection with independent component analysis (ICA) of sound signals it is known to arrange at least one of the detectors close to the target sound source I order to achieve enhanced signal to noise ratio from this detector, see D1, figure 7. In many devices such as hearing aids this is not a option, which limits there benefits of using in connection with these devices. The invention seeks a solution to this problem and by the feature of the independent claims

According to claim 1 this is done by using microphones with mutually different directionality whereby it is ensured that one of the input signals has a better signal to noise ratio with respect to the target signal than the other input signals. By doing this, the independent component analysis (ICA) can use input signals as the target signals and thereby the performance of the ICA may be enhanced.

D1 does not mention the use of microphones with different directionality in connection with the ICA method. It neither suggests it in an obvious manner.

Therefore the combination of features according to the present claim 1 is neither disclosed nor rendered obvious by the disclosure of document D1.

Moreover there is no indication in the remaining available prior art which suggests the combination as in present claim 1.

Therefore the subject-matter of the independent claim 1 currently on file is novel and involves an inventive step according to the criterion set forth in Article 33(2) and 33(3) PCT in conjunction with Rules 64(1)-(3) and 65(1)(2) PCT.

Claims 2-4

2.3). The dependent claims 2-4 define particular embodiments of claim 1 which are not considered obvious in view of the available prior art.

Claim 5

2.4). Independent claim 5 defines another way of solving the problem. It consists in making use of a beamforming. At least two microphones are used and the beamforming will add directivity to a signal which is fed to an input channel of the signal processing means together with a microphone signal without beamforming. In this way directionality and thus improved signal to noise ratio is ensured for one of the signal processing means and thereby enhanced ICA performance is ensured.

D1 does not mention the use of beamforming in connection with the ICA method. It neither suggests it in an obvious manner.

Therefore the combination of features according to the present claim 5 is neither disclosed nor rendered obvious by the disclosure of document D1.

Moreover there is no indication in the remaining available prior art which suggests the combination as in present claim 5.

Therefore the subject-matter of the independent claim 5 currently on file is novel and involves an inventive step according to the criterion set forth in Article 33(2) and 33(3) PCT in conjunction with Rules 64(1)-(3) and 65(1)(2) PCT.

Claim 6

2.5). Claim 6 defines a hearing aid having substantially the same features as the device claimed in the present claim 1.
Therefore the subject-matter of the independent claim 6 currently on file is novel and involves an inventive step according to the criterion set forth in Article 33(2) and 33(3) PCT in conjunction with Rules 64(1)-(3) and 65(1)(2) PCT.

Re Item VII
Certain defects in the international application

1). The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

2). The document D1 has not been identified in the description nor has the relevant background art disclosed therein been discussed. The requirements of Rule 5.1(a)(ii) PCT are, thus, not fulfilled.

3). The description is not in conformity with the claims as required by Rule 5.1(a)(iii) PCT, see also PCT/GL/IPE III-4.3.